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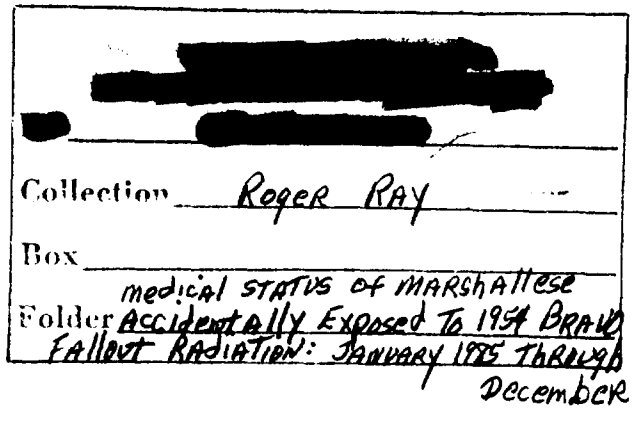
MEDICAL STATUS OF MARSHALLESE ACCIDENTALLY EXPOSED TO 1954 BRAVO FALLOUT RADIATION: JANUARY 1985 THROUGH DECEMBER 1987

William H. Adams, M.D., Peter M. Heotis,
and William A. Scott



MEDICAL DEPARTMENT

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DEDICATION

This report is dedicated to the captain and crew of the M.V. Liktanur. For ten years the Liktanurs II and III have served as home and workplace for much of each medical mission to the Marshall Islands. Throughout this time it has been the good fortune of the medical program to have the excellent support of the ship's crew. More importantly, that good fortune was extended to the population served by the medical team; the emergency rigging of oxygen tanks to treat hypoxic patients, lighting of a small airstrip at night to facilitate an emergency air evacuation, radio liaison, transport of patients between the atolls and to and from shore, and the emergency repair of medical equipment are just some of the nonnautical activities that benefited the medical missions. Now, a new support vessel for work in the Marshall Islands has come under contract to the Department of Energy. Therefore, on the departure of the Liktanur, we would like to acknowledge our debt to Capt. Keith Coberly; Monroe Wightman, engineer; Jim Whitney and Jan Kocian, first mates; Cisco Peru, cook; Les Nunes, boatswain; Tony Ned and Mathan Almen, seamen; and other crew members who, for shorter periods, also contributed to the effectiveness of the missions. We thank them for a job well done.

IN MEMORIAM

Two former members of the Brookhaven medical team who participated in several surveys died during the past year. Colonel Austin Lowrey, Jr., died at the age of eighty-six. He was a well-known ophthalmologist with a long career in the army. He was a most kind and generous person and contributed a great deal to the evaluation of possible radiation effects on eyes. Dr. Leo Meyer, who died at age eighty-two, was a well-known hematologist and was Director of the Sickle Cell Anemia Program of the Veterans' Administration. He made outstanding contributions to the program in evaluating hematological radiation effects. Leo will be remembered for his joviality, for always having a joke ready to cheer us. Both of these men were well liked by medical teams and the Marshallese people, and we shall truly miss them.

Robert A. Conard, M.D.
January 23, 1989

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INTRODUCTION

This report updates, through 1987, the medical findings on a population of Marshallese accidentally exposed to radioactive fallout in 1954. The Marshall Islands Medical Program of the Medical Department, Brookhaven National Laboratory, issues these summaries for distribution to institutions and individuals worldwide who are concerned about the adverse medical consequences of radiation exposure in general or, in particular, the plight of the radiation-exposed Marshallese.

The exposed Marshallese population originally comprised 64 persons on Rongelap Atoll who received an estimated 190 rads of whole-body external gamma radiation, 18 on Ailingnae Atoll who received 110 rads, and 159 on Utirik Atoll who received 11 rads. In addition, there were 3 fetuses on Rongelap, 1 on Ailingnae, and 8 on Utirik, each of which received equivalent whole-body doses. Because of radioiodines in the fallout, the thyroid gland received an additional exposure that was much greater than the whole-body dose, although its magnitude was, in part, a function of age at the time of exposure (Lessard et al., 1985).

The content of this report is restricted to the more recent medical findings, some aspects of which bear on late effects of radiation exposure. Those features of the Marshall Islands Medical Program by which medical diagnosis and treatment are provided are discussed. For detailed information on the nature of the 1954 fallout and the acute effects suffered by the population, the reader is referred to several earlier publications (Bond, et al., 1955; Cronkite et al., 1955; Cronkite et al., 1956; Conard et al., 1957). Other reports provide reviews of delayed effects of the exposure (Conard et al., 1980; Conard, 1984; Robbins and Adams, 1989).

EXPOSURE GROUPS

The medical program examines and treats about 800 persons annually. However, the populations on which this report is based include only the exposed persons and a selected group of unexposed individuals. In December 1987, the number of exposed persons was: Rongelap - 50, Ailingnae - 12, and Utirik - 112. For most purposes in this report the Rongelap and Ailingnae groups are combined and referred to as the Rongelap group, for those persons exposed on Ailingnae atoll were visiting from nearby Rongelap at the time of the fallout. Also examined was the Comparison group that dates from 1957 when 86 unexposed people from Rongelap were selected so that the Comparison group approximated, in age and sex distribution, the exposed Rongelap group (Conard et al., 1958). Sixty persons remain in this group, against which the overall survival of the exposed population is compared (Figure 1). However, a larger unexposed group is also followed. Currently numbering 135, the age and sex distributions of its members were statistically similar to those of the Rongelap and Utirik groups in 1982 (Adams et al., 1983). Included among the 135 are most of the remaining 60 individuals selected in 1957. It is this expanded unexposed population that is used for statistical comparisons of year-to-year medical events; this provides the baseline prevalences from which any unexpected consequences of the radiation exposure can be identified.

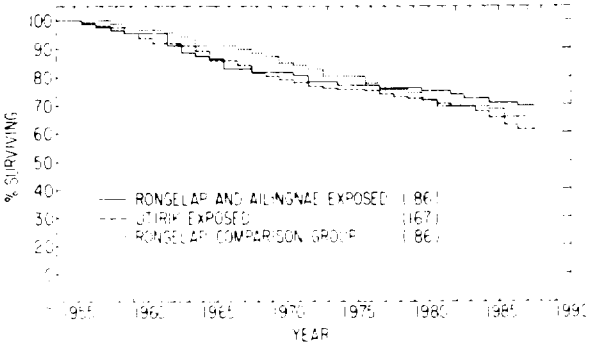

Fig. 1: Percent survivors of the different exposure groups since 1964. The number of persons in each group are given in the parentheses.

THE MARSHALL ISLANDS MEDICAL PROGRAM

Policies:

The Marshall Islands Medical Program provides medical care twice yearly to the exposed population by visiting the islands where most now reside, namely Rongelap (and, temporarily, Mejato), Utirik, Ebeye, and Majuro. In addition, the medical team provides health care to a con-

siderable number of unexposed persons. All the inhabitants of Rongelap, Mejato, and Utirik are eligible for medical attention at the time of the team visits to those islands. Team physicians need not be aware of the status of radiation exposure of the individual patient because health care delivery is the same for everyone. The only difference allotted to the exposed population is a U.S. Department of Energy-sponsored referral system to the Marshallese health care system or to tertiary care facilities in the United States for diseases that can reasonably be considered to be radiation-related or for diagnosis of such diseases. Unexposed persons are directed into the referral channels of the Health Services of the Republic of the Marshall Islands whereby referrals are assigned on the basis of priorities set by a medical committee in Majuro.

Any exposed person who has, or who might have, a malignant neoplasm, is referred to secondary or tertiary medical facilities for a definitive evaluation and for therapy if a lesion is found. The usual hospitals to which patients are referred are in Honolulu and Cleveland, the latter because of the presence there of a preeminent thyroid surgeon who has long been involved with the exposed and Comparison groups of Marshallese.

The medical program also dispenses primary medical care and preventive medical services, such as immunizations, during visits to the exposed population. In bringing modern facilities for diagnosis and treatment of disease to the exposed Marshallese, the physicians of the medical program come into contact with children and other family members of the exposed, as well as other inhabitants of the islands. It has been the policy of the Department of Energy to support the medical program in its efforts to provide primary medical care to these individuals on the basis of humanitarian need and as resources permit.

The medical direction of the Marshall Islands Medical Program and the organization of the medical missions to the Marshall Islands are centered at Brookhaven National Laboratory. The staff of the program includes a physician-director, an administrator, and a technical specialist at the Laboratory, and a Marshallese laboratory technician on Ebeye. At the time of the missions a variety of physicians are chosen for the medical team. They are skilled volunteers, primarily faculty from medical schools, often with past experience with the program. Logistical support is provided by the Department of Energy, capably facilitated by Holmes and Narver, Inc., Honolulu, HI. The Marshall Islands government, as requested, temporarily assigns nurses, translators, and other health care workers to each mission.

Although there are two medical missions each year, in the interim the exposed population has access to the Marshallese health care system. To expedite exchange of medical information, copies of all examination and laboratory data from the Marshall Islands Medical Program are forwarded to the Marshall Islands Health Service hospitals on Ebeye and Majuro and to the special programs set up for persons from the radiation-affected atolls, currently the 177 Health Care Plan with administrative offices at the Majuro hospital. In addition, copies of the examinations and laboratory data are given to the examinees.

A computer program with data base was developed for portable (lap-top) computers. Computerization of the clinical data permits rapid access while in the field to all findings obtained during the preceding five years of examinations and to selected data collected over more than thirty years. It is hoped that in the near future the development of compatible programs by the Marshallese 177 Health Care Plan will permit sharing of up-to-date problem lists and other medical record items that are important to effective continuity of care.

The Marshall Islands Medical Program, as a satellite clinic of the Clinical Research Center, Brookhaven National Laboratory, is accredited by the Joint Commission on Accreditation of Healthcare Organizations, a nationwide organization that sets standards of performance for institutions dispensing medical care and monitors compliance with those standards. By voluntary participation in the accreditation process, the Marshall Islands Medical Program receives a valuable and impartial external review of its policies and procedures, as well as an assessment of the adequacy of the services it provides. Laboratory and radiological services, medical records, patient satisfaction, pharmaceutical services, and clinical competence of physicians are among the many items reviewed by the Joint Commission.

Much medical data unrelated to radiation exposure is acquired during each medical mission. Some of this information, from exposed and unexposed individuals, is relevant to health care throughout the Marshall Islands. Consequently, public health reports, based on medical team observations unrelated to radiation, have been submitted periodically to the Health Services of the Republic of the Marshall Islands. The topics during this reporting period have included the following:

1) Serum lipids in Marshallese
2) Pediatric growth and development (an analysis prompted by observations of medical team physicians that Rongelap children, following their transfer to Mejato, were not maintaining their positions on charted growth curves)
3) Pediatric audiometry
4) Dental conditions on Rongelap and Utirik
5) Chlamydia infections in Marshallese women
6) Large optic disks (a relatively frequent finding by medical team ophthalmologists)

Some significant observations in these and earlier public health reports were published in medical journals. Moderately elevated serum uric acid levels were noted in many Marshallese and the frequency of this finding and that of gout were analyzed (Adams et al., 1984). Toxoplasmosis was identified as a serious health hazard in the Marshall Islands, with an estimated 200 persons being visually impaired and an incidence of chorioretinitis of 273 cases/ year 100,000 seropositive persons (Adams et al., 1987). Hepatitis B, the subject of a serological survey described in a previous Brookhaven National Laboratory report (Adams et al., 1985), constituted another serious public health problem (Adams et al., 1986). The prevalence of anemia in children was described, and normal ranges for hemoglobin level and erythrocyte mean corpuscular volume for Marshallese children were derived (Dungy et al., 1987). The latter were found to be identical to those of children in the United States. Because of the devastating effects of diabetes mellitus among the Marshallese, an effort was made to determine if a dietary deficiency of chromium, a trace element that is relevant to glucose tolerance, contributed to the problem. The analytic procedure used was too insensitive to quantitate blood levels of chromium, but during the analysis it was found that bromine levels were higher than those reported for any other population (Wielopolski et al., 1986). The reason for this is unknown; further, the levels of bromine that were detected fall far short of its known toxic levels. The observation by team ophthalmologists of large optic disks in many persons prompted another report to the Marshallese Health Services because the associated increase in disk cupping could be misconstrued by physicians as representing glaucoma. The high prevalence of the condition indicates Marshallese are unique among all populations in whom such measurements have been obtained (Maisel et al., 1989).

Procedures:

The exposed population, which now numbers 163, must be considered at increased risk for malignant disease as a late complication of radiation injury. Therefore, the medical program has in place a cancer-oriented annual health evaluation. The examination follows the guidelines of the American Cancer Society and includes a medical history, complete physical examination, advice on decreasing risk factors for cancer, advice on self-detection of lesions, annual pelvic examinations and Papanicolaou smears, stool testing for blood, blood count, and urinalysis. Several new diagnostic procedures were incorporated into the medical missions in the past three years. Because of the development of x-ray films and cassettes that significantly decrease radiation exposure, annual mammography is offered to all exposed women and to all unexposed women forty years of age or older. For persons over the age of fifty years, flexible sigmoidoscopy is offered every three years or whenever clinically indicated. An ultrasound machine has been acquired that greatly increases the diagnostic capabilities of the medical team, especially in managing acute problems seen at the time of team visits. For thyroid diagnosis, needle biopsy of selected thyroid nodules has been instituted in an effort to avoid surgery and the subsequent loss of normal thyroid tissue in patients with benign nodular lesions. Because of earlier medical program observations it is known that the exposed are at greater risk for certain endocrine problems and for this reason they receive annual thyroid-

function blood tests and thyroid examinations by a specialist in endocrinology or thyroid surgery. Other tests are performed on a regular basis in an attempt at early detection of malignant nonthyroidal lesions. There is also ongoing monitoring for clinical evidence of immune competence, for exposed persons may be at increased risk for unusual manifestations of infectious diseases.

Medical examinations and services performed during this three-year reporting period were conducted primarily aboard the Liktanur II and the Liktanur III, vessels chartered from U.S. Oceanography. Exceptions, as in the past, included the use of Brookhaven National Laboratory facilities on Ebeye and, when necessary, Marshallese medical dispensaries on Rongelap, Utirik, and Mejato. Laboratory support during the medical missions is provided by several technicians. Routine blood counts are performed on a J.T. Baker 5000 electronic particle counter and sizer. Leukocyte differentials and phase contrast platelet counts are part of each hemogram. A variety of nonhematological testing services is provided, including bacteriology, stool examination, and urine testing. In the past a battery of manual clinical chemistry tests was carried out using commercial spectrophotometric kits. Recently, however, Eastman-Kodak's DT-60 and DTSC analyzers were added to increase the variety of chemistry tests available in the field and to improve the turn-around time for results; this has significantly improved laboratory operation. Fortunately, there have been few problems associated with transport, operation, and handling of the new equipment on board ship, even during bad weather. A Beckman Electrolyte 2 analyzer is used to measure sodium and potassium in serum and urine. Roentgenographic services are performed with a Bennett standard x-ray unit and mammography unit, both of which are contained in a separate module on the deck of the ship. Serum is usually collected from most examinees and frozen for subsequent testing. Referral laboratories have included Bio-Science Laboratories and Accupath in Honolulu for special chemistries and serologies; Pathologists' Laboratories, Inc., Honolulu, for Papanicolaou smears and other cytology; Brookhaven National Laboratory's clinical laboratory for general chemistry and alpha fetoprotein analysis; Hazelton Biotechnologies Co., Vienna, VA, for hormone assays; Michael Reese Hospital and Medical Center (Dr. A. B. Schneider, Department of Endocrinology and Metabolism), Chicago, for thyroglobulin analysis; Medical Microbiology Division, University of California, Irvine, for chlamydia culture and serology; and the Eugene L. Saenger Radioisotope Laboratory, University of Cincinnati, for antimicrosomal and antithyroglobulin antibody testing (Dr. Harry Maxon).

The Marshall Islands Medical Program is deeply indebted to the many outstanding physicians who, despite the inevitable personal inconvenience, participated in the medical team visits of 1985-1987. It is fair to say that they are the heart of the program. Drawn from excellent medical centers throughout the United States and from private practices, these physicians provide the program with a wide range of up-to-date clinical experience and perspective that contribute to better patient care. The physicians involved in the 1985-1987 missions are listed in Appendix A, and represent the following medical specialties:

Internal Medicine
Pediatrics
Infectious Disease
Cardiology
Obstetrics/Gynecology
Ophthalmology
Endocrinology
Surgery
Gastroenterology
Family Practice
Geriatrics
Allergy/Immunology
Dermatology
Neurology
Pediatric Dentistry

The participation of many excellent medical specialists undoubtedly has been a major factor in the acceptance of the Marshall Islands Medical Program by the population it serves. The percent of persons in the exposed and Comparison groups who appear for the voluntary examinations remains high. For the current reporting period the annual acceptance rates were:

	1985	1986	1987
Rongelap	82%	93%	95%
Utirik	92%	92%	90%
Comparison	76%	66%	72%

The percent of the eligible population examined on at least one occasion during the three year period was:

Rongelap	97%
Utirik	100%
Comparison	94%

These figures do not include several persons residing outside the Marshall Islands. Most exposed persons in this category have medical examinations arranged through a local physician by the Department of Energy or the Marshall Islands Medical Program. The acceptance rate for mammography among eligible women was 100%. For sigmoidoscopy, about 50% of age-eligible persons elect to undergo this procedure on a regular basis.

MEDICAL FINDINGS

Overall Survival:

After thirty-three years there continues to be no significant difference in the survival curves of the high-exposure Rongelap group, the low-exposure Utirik group, and the unexposed Rongelap population followed for the purpose of comparison (Fig. 1). Estimates of the survival distribution by the actuarial life table method were analyzed by Mantel-Cox and Breslow statistics for testing the equality of the survival curves. The "p" values were 0.68 by both techniques. In the Brookhaven National Laboratory report covering January 1983 through December 1984, it was noted that Okajima et al. (1985) suggested that medical programs providing health screening might lead to an underestimation of the effect of radiation on mortality. In particular, it was postulated that this could explain the lower age-specific death rates from all causes among Nagasaki A-bomb survivors, compared to a control population. The effect of medical examinations on the survival of the exposed Marshallese is unknown. On the one hand about 15 percent of the Comparison group selected in 1957 is no longer seen because those individuals have voluntarily foregone examination. In addition, BNL referrals for the Comparison group are channeled into the Marshallese Health Services system, whereas selected medical problems in the exposed groups can be referred directly to tertiary care facilities in the United States. On the other hand, the exposed populations of Rongelap and Utirik have received equivalent medical attention from the BNL program since 1972, and yet, despite the far higher radiation dose received by the Rongelap group, the survival curves are similar.

Another factor that contributes to the difficulty in interpreting differences in the group survivals in Fig. 1 is that the population used to construct the "Rongelap unexposed" curve was selected in 1957, and it is in that year that their survival is graphed as one-hundred percent; i.e., data from three years of observation, during which some deaths occurred, had already been acquired from the two exposed populations.

Causes of Recent Mortality:

The number of deaths occurring in the last three years are as follows: Rongelap exposed - 2; Utirik exposed - 9; Comparison group - 10. The specific clinical situations are described below.

Rongelap

Subject No. 1. The causes of death listed on the death certificate of this 81-year-old woman in June 1985 were "Inanition" and "Senility." When seen in March 1985, she had a normal blood pressure and cardiac examination revealed "premature beats." In 1984 she was noted to have cataracts, atrial fibrillation, and complaints of urinary incontinence, some cough, constipation, and joint pains. Her hemoglobin was 12.7 g/dl, the mean corpuscular volume was 92 fl, and the white blood cell count was 6,600 per ul with a normal differential.

Subject No. 11. This 81-year-old man died in 1987 of unknown cause. Diagnoses made during the preceding four years included severe osteoarthritis, chronic obstructive pulmonary disease with bullous emphysema, macrocytic anemia that was being treated with vitamin B12 injections, cataracts, and "organic brain syndrome." He had declined a medical examination when visited at his home in September 1986, but did not appear acutely ill at that time.

Utirik

Subject No. 2123. This 47-year-old man died in December 1986 from biopsy-proven hepatocellular carcinoma. His alpha fetoprotein level was elevated and the serum contained hepatitis B surface antigen but no delta antibody. No evidence of tumor was found at his March 1986 examination. Symptoms related to the tumor developed in June of that year.

Subject No. 2125. This patient died in 1987 from carcinoma of the lung with brain metastases at age 70. He had been referred to a Honolulu hospital for evaluation of guaiac-positive stools in October 1986. A chest x-ray was negative at the time of referral. No serious problems were detected during his Honolulu examination, but respiratory symptoms from the tumor developed in January 1987. He had been a cigarette smoker, and was felt to have severe chronic obstructive pulmonary disease with recurrent bronchitis.

Subject No. 2128. This 39-year-old woman had diabetes mellitus complicated by chronic renal failure, severe diabetic retinopathy and neuropathy, and anemia (hemoglobin 9.4 g/dl in October, 1984). She died in a Honolulu hospital after emergency air evacuation from Utirik. Diagnoses made at the hospital included hypoglycemic and hypoxemic brain damage, diabetes mellitus treated with insulin, anemia secondary to renal failure, and sepsis.

Subject No. 2164. "Postpartum hemorrhage" and "uterine inertia" were listed on the death certificate of this 42-year-old woman in February 1985. Previous problems included obesity and possible gout. A blood count in March 1984 was normal.

Subject No. 2189. This 59-year-old woman died in 1987 from chronic renal failure due to diabetes mellitus. Her serum creatinine in March 1986 was 10.9 mg/dl and the hemoglobin level was 7.7 g/dl.

Subject No. 2200. "Inanition" and "senility" were the death certificate diagnoses for this 72-year-old woman who died in December 1985. A thyroid nodule had been noted at least since 1977 but the patient "appeared to be a poor surgical risk." Her hemoglobin level was 11.6 g/dl and the white blood cell count was 6,200 per ul. A left breast mass had been noted since 1966, but the patient had declined biopsy and surgery. She said the mass had been present since youth.

Subject No. 2212. This 66-year-old woman died in 1987 from chronic renal failure due to diabetes mellitus. She was evaluated at Kwajalein hospital in 1985 and noted to have renal failure, hypertension, and anemia. When evaluated by physicians of the 4-Atoll Healthcare Program she was not felt to be a candidate for dialysis, and her family agreed to supportive management.

Subject No. 2218. The death certificate diagnosis on this 34-year-old woman in September 1985 was "congestive heart failure." When examined in March 1985, the only significant abnormality had been a urinary tract infection for which she was given an antibiotic, although asthma had been noted in the past. The patient was late in pregnancy at the time of her demise and was, on the basis of history obtained from the 4-Atoll program physicians, probably eclamptic.

Subject No. 2249. This woman died at age 57 in February 1986 from complications directly arising from local extension of a "malignant meningioma." A description of this patient and the tumor was presented in a previous BNL report (Adams et al., 1983) following the original diagnosis in 1982.

Comparison group

Subject No. 814. The death certificate diagnosis in June 1985 for this 33-year-old man was pneumococcal meningitis confirmed by culture. He worked on Kwajalein and died in Kwajalein hospital after being transferred from Ebeye hospital. His most recent BNL medical examination had been in April 1983, when problems of smoking and heavy alcohol consumption were noted. His blood count was normal at that time.

Subject No. 821. This 38-year-old woman died in 1986 from complication of childbirth, her death certificate diagnosis being "postpartum hemorrhage." When seen in April 1986 she was 22 weeks into her thirteenth pregnancy. No significant abnormalitites were noted at that time.

Subject No. 842. The death certificate diagnosis on this 61-year-old man in March 1986 was "liver failure due to hepatoma." The only active problem noted in his last BNL medical examination in March 1985 was chronic low back pain. A routine sigmoidoscopic examination was normal except for the presence of hemorrhoids. Hepatitis B surface antigen was not detected in his serum, but antibody to the surface antigen was present.

Subject No. 846. This 63-year-old woman underwent a bone marrow aspiration in March

1986 for evaluation of anemia and leukopenia. The diagnosis of refractory anemia with excess blasts was made and subsequently confirmed in Honolulu at the Straub Clinic ("myelodysplastic syndrome with an evolving acute nonlymphocytic leukemia"). She died in 1986.

Subject No. 928. The cause of death in 1987 of this 73-year-old woman is unknown. When last seen by the BNL medical team in Majuro in March 1986, no serious medical illnesses were noted. She had been moderately anemic for several years (hemoglobin level between 10.5 and 11.5 g dl), and a flexible sigmoidoscopic examination in 1985 was normal. No gastrointestinal blood loss was documented in recent years.

Subject No. 950. This 40-year-old woman died in Kwajalein hospital in August 1985. The death certificate diagnoses were essential hypertension and intracerebral hemorrhage. She had been known to be hypertensive for 13 years and was followed in the hypertension program of the Trust Territories.

Subject No. 969. The clinical diagnosis in this 69-year-old man was either metastic tumor to the lung or pulmonary tuberculosis. However, the 1987 death certificate diagnoses were "congestive heart failure" and "pneumonia." Sputum cultures for *M. tuberculosis* were negative and there was no clinical response to antituberculous therapy.

Subject No. 975. When splenomegaly and thrombocytopenia were detected in March 1984, this 65-year-old man was referred for further evaluation. A lymph node biopsy in October 1984 showed "atypical lymphoepithelioid cell proliferation of uncertain etiology," possibly a lymphoma. He died in 1985 and details of the terminal illness could not be obtained.

Subject No. 991. This 78-year-old woman died in January 1986. Death certificate diagnoses included "septicemia, diabetes mellitus, and chronic renal failure from diabetic nephropathy." She had a mid-calf amputation of the right leg some six years earlier and was being followed at the Ebeye hospital. Her most recent BNL medical examination was in 1981.

Subject No. 1050. Colon carcinoma with hepatic metastases is the death certificate diagnosis in March 1985 for this 50-year-old woman. This diagnosis was made after she was referred to Majuro for evaluation of a possible abdominal mass detected in June of 1984.

Laboratory Findings:

A review of average blood cell counts of the different exposure groups during the three-year reporting period does not reveal any systematic differences among groups. Figure 2 is a continuation graph in which the exposed groups are portrayed in relation to the Comparison group. Table 1 gives the actual mean counts of formed blood elements of the different groups and identifies counts which differed significantly from those of the Comparison group.

Biochemical test results are listed by individual identification number in Appendix B.

Neoplasms:

Thyroid nodules

Surgery for palpable thyroid nodules was performed on five persons in 1985 and one person in 1986. No new lesions were detected in 1987. The specific diagnoses, determined by an expert panel of pathologists, are listed in Table 2, and Table 3 gives a summary of all nodules diagnosed throughout the medical program. The benign thyroid nodules include adenomas, adenomatous nodules, and occult papillary carcinomas. The adenomatous nodules are included in the tabulation even though it is highly debatable that they are true neoplasms. The occult papillary carcinomas are, with rare exceptions, "harmless tumors" (Sampson, 1976). A recently reported autopsy series from the Federal Republic of Germany found occult papillary carcinomas in 6.2% of 1020 thyroid glands. Almost half of the tumors were multicentric and 14% had regional lymph node metastases (Lang et al., 1988). Since there was no predilection for age it was concluded, as in earlier studies, that occult papillary carcinomas have no propensity to cause clinically apparent thyroid disease. However, controversy continues on how the clinical diagnosis of occult papillary carcinoma is to be made (Schneider et al., 1980), and some authorities would accept that diagnosis only if the tumor were an incidental finding at surgery. Since some of the purported occult papillary carcinomas removed from the Marshallese patients presumably were palpable before surgery, there may by differing opinions on their clinical, if not histologic, classification.

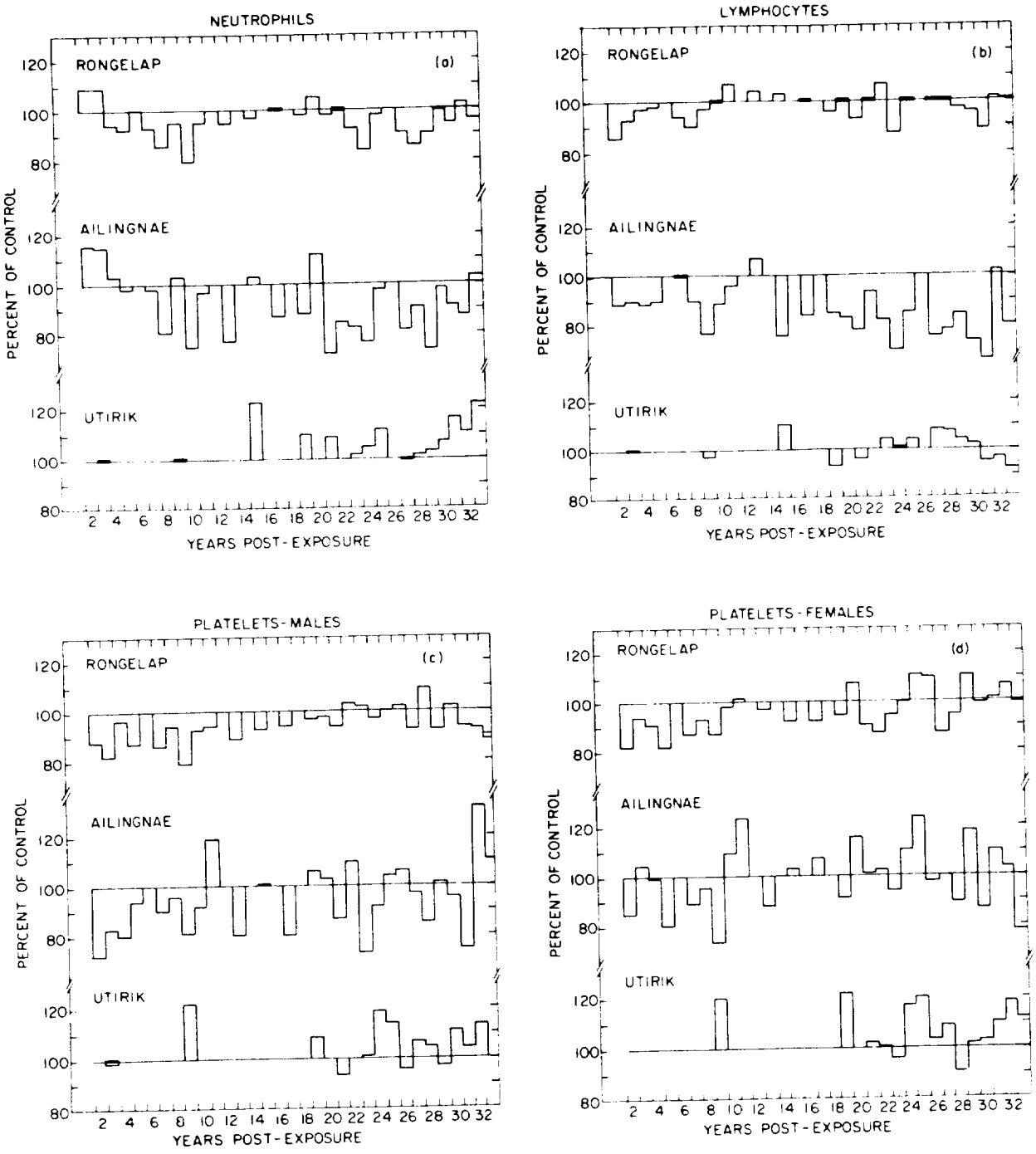

Fig. 2: Annual mean blood cell counts of the different exposure groups (age 5 years or more) expressed as percent of control, beginning two years after exposure. Values for both sexes are grouped for neutrophils and lymphocytes. Detailed annual observations, including blood cell counts, on the Utirik population did not begin until 1973. Leukocyte differentials and platelet counts were not obtained for six and five of the examinations, respectively, but for graphing purposes the 100% line has not been broken at those years.